

**PATENT OFFICE  
JAPANESE GOVERNMENT**

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application: August 24, 1999

Application Number: Patent Application No. 11-237061

Applicant(s): OLYMPUS OPTICAL CO., LTD.

This 28th day of July 2000

Commissioner,  
Patent Office

Kozo OIKAWA (seal)

Certificate No.2000-3059896

[Name of Document] PATENT APPLICATION

[Reference Number] A009904845

[Filing Date] August 24, 1999

[To] Commissioner, Patent Office

[International Patent Classification]

G03B 17/00

[Title of the Invention] ELECTRONIC CAMERA

[Number of Claims] 2

[Inventor]

[Address or Residence] 43-2, Hatagaya 2-chome,  
Shibuya-ku, Tokyo c/o  
OLYMPUS OPTICAL CO., LTD.

[Name] Dai Kawase

[Inventor]

[Address or Residence] 43-2, Hatagaya 2-chome,  
Shibuya-ku, Tokyo c/o  
OLYMPUS OPTICAL CO., LTD.

[Name] Masayu Higuchi

[Applicant for Patent]

[Identification of Number] 000000376

[Name] OLYMPUS OPTICAL CO., LTD.

[Agent]

[Identification of Number] 100058479

[Attorney]

[Name] Takehiko Suzuye

[Phone Number] 03-3502-3181

[Appointed Agent]

[Identification of Number] 100084618

[Attorney]

[Name] Sadao Muramatsu

## [Appointed Agent]

[Identification of Number] 100068814

## [Attorney]

[Name] Atsushi Tsuboi

## [Appointed Agent]

[Identification of Number] 100100952

## [Attorney]

[Name] Tetsuya Kazama

## [Appointed Agent]

[Identification of Number] 100097559

## [Attorney]

[Name] Koji Mizuno

## [Indication of Official Fee]

[Prepayment Register Number] 011567

[Amount of Payment] ¥21000

## [List of Items Submitted]

[Name of Item] Specification 1

[Name of Item] Drawing 1

[Name of Item] Abstract 1

[Number of General Power of Attorney] 9602409

[Necessity of Proof] Necessary

- 1 -

[Document] SPECIFICATION  
[Title of the Invention] ELECTRONIC CAMERA  
[What is Claimed is:]

## [Claim 1]

An electronic camera characterized by comprising an image sensing element composed of a single panel and having a pixel corresponding to at least three different color information, characterized in that

the camera further comprises interpolation means for generating a plane that corresponds to number of all pixels by interpolation processing based on an approximate expression including a polynomial of at least 3rd-order with use of pixel values having color information same as that of the pixel.

## [Claim 2]

The electronic camera according to claim 1, characterized in that the interpolation means further comprises a table storing an interpolation coefficient, and the interpolation means interpolates the pixel using the interpolation coefficient stored in the table.

## [Detailed Description of the Invention]

[0001]

## [Technical Field of the Invention]

The present invention relates to an electronic camera which can electronically sense an object image and display and record obtained image information, in particular, relates to an electronic camera capable of processing a pseudo 3-CCD processed image with use of an image sensing element composed of a single panel.

- 2 -

[0002]

[Prior Art]

An image pickup apparatus is disclosed, in this apparatus, to avoid a false signal at an edge portion in pixel interpolation, two images are generated by spatial pixel shift, and a synthesized image thereof is obtained. (Jpn. Pat. Appln. KOKAI Publication No. 10-248069)

[0003]

[Object of the Invention]

The present invention has its object to provide an inexpensive and high-quality-image electronic camera by pseudo 3-CCD processing an image photographed by an image sensing element composed of at least a single panel.

[0004]

[Means for Achieving the Object]

The present invention takes a following measure to solve the above objects.

[0005]

An electronic camera according to the present invention is characterized by comprising an image sensing element composed of a single panel and having a pixel corresponding to at least three different color information, in which the electronic camera further comprises an interpolation means for generating a plane that corresponds to number of all pixels by interpolation processing based on an approximate expression including a polynomial of at least 3rd-order with use of pixel values having color information same as that of the pixel. In this manner, pseudo 3-CCD processing can be performed by high-

- 3 -

quality interpolation, an inexpensive and high-quality image electronic camera can be provided

[0006]

In the above-described electronic camera, the interpolation means further comprises a table storing an interpolation coefficient, and the interpolation means interpolates the pixel using the interpolation coefficient stored in the table. Interpolation calculation is executed by looking up the table prepared in advance to avoid complex calculation. Hence, this allows high-speed processing and requires no high-performance arithmetic element.

[0007]

[Embodiment of the Invention]

An embodiment of the present invention will be described below with reference to the accompanying drawing.

[0008]

FIG. 1 is a schematic block diagram showing the system arrangement of an electronic camera according to an embodiment of the present invention. The schematic arrangement of the electronic camera according to the present invention will be described with reference to FIG. 1.

[0009]

An object image that has passed through an image sensing lens system 11 is converted into an electrical signal by an image sensing element 12. The electrical signal converted by the image sensing element 12 is converted into an analog image signal by an image sensing circuit 13 and then into a digital image signal by an A/D converter 14. This digital image

- 4 -

signal is subjected to a series of image processing operations and then recorded in a detachable memory 20 as an external memory (e.g., a flash memory or smart medium) through an interface (I/F) 21. The detachable memory 20 is normally inserted into a card slot 22. The electronic camera also has an internal memory 30 (e.g., a RAM (Random Access Memory)) which operates at a high speed and is used as a working memory in image compression and expansion, or an image storing means, that is, a high-speed buffer for temporarily storing various image data. In the present invention, the internal memory 30 has a memory area 31 for interpolation processing. This memory area 31 can be prepared independently of the internal memory 30 or incorporated in an interpolation calculation circuit (or IC).

[0010]

A compression/expansion section 40 compresses the digital image signal or expands (elongates) the compressed image signal.

[0011]

The electronic camera normally has an LCD 50 (liquid crystal display device) for displaying an image. The LCD 50 is used to confirm an image recorded in the detachable memory 20 or display an image to be sensed. An image can be displayed on the LCD 50 by temporarily loading image information from the internal memory 30 to a video memory 51 and converting the image information into a video image by a video output circuit 52. The output from the video output circuit 52 can be output to an external display device as a

- 5 -

video image through an external terminal 53 for video output.

[0012]

A system controller 70 systematically controls the sections of the electronic camera. The detailed functions of the system controller 70 will be described later. The system controller 70 receives an input from an operation section 73 formed from a release button and senses an image in accordance with the operation of the release button, or requests an image processing circuit (not shown) to process an image. If the light amount in sensing an object is too small, the system controller 70 requests and controls an electronic flash light-emitting section 71 to turn on the electronic flash for image sensing. The system controller 70 also has an image sensing distance detection section (not shown) having a function of detecting the distance from the object. The operation section 73 can set various modes. The mode setting is displayed on a mode LCD 72.

[0013]

An external interface (external I/F) 61 is connected to an external input/output terminal 60 to input/output data from/to an external device. The external input/output terminal 60 is connected to, e.g., a personal computer to transfer an image in the detachable memory 20 to the personal computer or receive image data from the personal computer.

[0014]

The sections of the electronic camera are basically driven by a battery. Power supplied from a camera battery 81 through a power supply section 80 drives the sections of the



- 6 -

camera. The camera battery 81 can be charged under the control of the power supply section 80.

[0015]

FIGS. 2(a) and 2(b) are graphs showing one-dimensional interpolation models. Conventionally, linear interpolation of calculating an output value at a desired position using a line connecting two points is generally used, as shown in FIG. 2(a). In this method, although only two points suffice as positions having known output values necessary for calculation, the output value obtained is merely the proportional average between the two points. For example, even when the maximum value or minimum value is present between the two points, it cannot be detected. In the present invention, to improve the interpolation accuracy, an output value at a desired position is obtained by an approximate expression using a multi-order polynomial of at least 3rd-order. FIG. 2 shows an example in which the coefficients of a 3rd-order polynomial are obtained from values at four points, and an output is obtained by substituting position data to an approximate expression using the obtained 3rd-order polynomial. This interpolation by an approximate expression using a 3rd-order polynomial is also called "cubic interpolation". Referring to FIG. 2, the coefficients of the 3rd-order polynomial are obtained from the output values at four positions  $(n-1)$ ,  $n$ ,  $(n+1)$  and  $(n+2)$ , the output value at a position  $x'$  is obtained from the 3rd-order polynomial, thereby obtaining an interpolation value at the desired position. If this processing is done using linear

- 7 -

interpolation, the position (n+1) is obtained as the position having the maximum value. Hence, no accurate position can be obtained, unlike the present invention.

[0016]

FIG. 3 is a block diagram showing the arrangement of the interpolation calculation circuit 90 in the present invention. The interpolation calculation circuit 90 comprises an interpolation position calculation section 91, interpolation position correction section 92, interpolation coefficient table 93, interpolation calculation section 94, and buffer memory 31. The functions of the interpolation position calculation section 91 to the interpolation calculation section 94 are controlled by the system controller 70. More specifically, the interpolation calculation circuit 90 performs the following operation.

[0017]

Original image data from the internal memory 30 is input to the interpolation position calculation section 91 and interpolation calculation section 94. On the basis of the input data, the interpolation position calculation section 91 calculates, e.g., the interpolation position  $x'$  between the point  $\underline{n}$  and the point (n+1) shown in FIG. 2(b). Next, on the basis of data from the memory area 31, the interpolation position correction section 92 corrects the interpolation position to a point closest to the point  $x'$ , which is one of points that divide the section between the point  $\underline{n}$  and the point (n+1) into, e.g., 16 equal parts. By correcting the interpolation position, the output at the corrected

- 8 -

interpolation position can be calculated using the interpolation coefficient table 93 prepared in advance. Hence, the output value at the interpolation position can be calculated fast without any complex calculation. As for an error by correction of the interpolation position, the interpolation coefficients are given in the table, and therefore, it is impractical to excessively finely set interpolation positions because the data quantity of the table increases. Relatively finely, e.g., equally dividing a section into 16 portions suffices in terms of accuracy and is practical because the data quantity is not so large.

[0018]

FIGS. 4(a) to 4(c) are views for explaining pseudo 3-CCD processing using interpolation calculation by an approximate expression using a higher-order polynomial.

As shown in FIG. 4(a), a single image sensing element has a predetermined color layout of R (red), G (green), and B (blue) in units of pixels. One pixel corresponds to one color. In the present invention, using interpolation by an approximate expression using a higher-order polynomial, a red interpolation value is embedded in pixels without red color information, a green interpolation value is embedded in pixels without green color information, and a blue interpolation value is embedded in pixels without blue color information, thereby implementing pseudo 3-CCD processing. This process is shown in FIG. 4(b). Thereafter, the pixel planes shown in FIG. 4(b) with pixel planes shown in FIG. 4(c) are replaced on the basis of relationships:

- 9 -

$$Y = aR + bG + cB$$

$$Cb = \alpha (B-Y)$$

$$Cr = \beta (R-Y).$$

[0019]

FIGS. 5(a) to 5(c) are views for explaining the interpolation method for the R, G, and B colors. Referring to FIGS. 5(a) to 5(c), each of (R), (G), and (B) represents that the color information is not present. FIG. 5(a) shows interpolation of R (red). In this case, R (red) color information at neighboring points ①, ②, and ③ having R (red) color information can be interpolated using data (16 R data) indicated by a broken line A in FIG. 5(a). R (red) color information at points ④, ⑤, and ⑥ can be obtained on the basis of data indicated by a broken line B in FIG. 5(a). Pieces of color information at all squares are obtained by such interpolation. For G (green), since pixels having G data and pixels having no G data are alternated, for example, (G) data of a hatched pixel is obtained using 16 data represented by a broken line C. B (blue) shown in FIG. 5(c) has the same layout as that of R (red), so data at a no-pixel portion can be interpolated by the same procedure as that for R (red). In this case, data for 16 pixels (16 data are used for two-dimensional interpolation using a 3rd-order polynomial, as described above) are prepared as an interpolation coefficient table. Hence, a small table suffices as an interpolation coefficient table. In addition, since interpolation coefficients are given by the table, and no complex calculation is necessary, pseudo 3-CCD processing

- 10 -

can be implemented using a small circuit.

[0020]

FIGS. 6(a) to 6(c) are views for explaining another interpolation method for the R, G, and B colors. In the example shown in FIGS. 5(a) to 5(c), to interpolate the R, G, and B colors, for, e.g., the R (red) region A shown in FIG. 5(a), the interpolation value is obtained from  $7 \times 7$  pixels (basically, a region containing  $8 \times 8$  pixels is extracted). For G (green) shown in FIG. 5(b), a rhombic region is set to obtain the interpolation value. When the interpolation value is obtained by the region setting method shown in FIGS. 5(a) to 5(c), R (red) and B (blue) can use the same effective band, though the effective band of G (green) is different from that of the remaining colors. This interpolation method is therefore not preferable. To avoid this, in the present embodiment, all the R, G, and B colors are interpolated using  $4 \times 4$  pixels. FIG. 6(a) shows interpolation of R (red), FIG. 6(b) shows interpolation of G (green), and FIG. 6(c) shows interpolation of B (blue). For example, referring to FIG. 6(a), when  $4 \times 4$  pixels are extracted, the extracted region has at least four R (red) pixels (i.e., four data). Using the four data, the interpolation value at a position  $\bigcirc$  shown in FIG. 6(a) is obtained by an approximate expression using a 3rd-order polynomial. G (green) and B (blue) are also interpolated according to the same procedure as that for R (red). Since the frequency band changes depending on the position and interpolation coefficient, pixel data is corrected by a

- 11 -

correction coefficient corresponding to the pixel position, as shown in FIGS. 6(a) to 6(c). Thus in this embodiment, since the number of interpolation pixels can be decreased, and the R, G, and B color data are generated using the same interpolation coefficient on the basis of same 4 X 4 pixels, the same effective band can be used.

[0021]

FIG. 7 is a view showing for explaining still another interpolation method for the G (green) plane. Referring to FIG. 7, a square region is extracted, like R (red) or B (blue), instead of extracting a rhombic region as shown in FIG. 5(b). Referring to FIG. 7, for example, data interpolated by (G) and that interpolated by [G] are added to obtain an interpolation value. This makes it possible to generate G (green) data using the same interpolation coefficient in the same pixel region as that of R (red) or B (blue), so the same effective band can be used. In addition, since the number of pixels used for interpolation is larger than that of the example shown in FIGS. 6(a) to 6(c), the accuracy increases.

[0022]

FIG. 8 is a schematic view showing the flow of pseudo 3-CCD processing. The output from the CCD is converted into a digital signal by the A/D converter and is branched to two signals. One signal is used for edge extraction, and the other signal is used for pseudo 3-CCD processing. The signal representing the edge of the image is extracted from the broadband signal of the image. Pseudo 3-CCD processing is

- 12 -

executed using the narrow-band signal of the image. The signal representing the extracted edge is synthesized with three image signals, and the synthesized signal is subjected to image processing. The process corresponding to "edge extraction processing" performs broadband processing by compensating the high bandwidth component to 3-CCD processing with an edge extraction processing in this manner. Signal used in the edge extraction processing contains many broadband components, for example, the G (green) signal generated in the embodiment shown in FIG. 5 is used.

[0023]

As described above, according to the present invention, for a pixel having, e.g., R (red) pixel information of the R, G, and B color information, G (green) and B (blue) pixel values are obtained by interpolation by an approximate expression using a higher-order polynomial, and for a pixel having no R (red) color information, the pixel value is obtained by similar interpolation. With this interpolation by an approximate expression using a higher-order polynomial, a more accurate interpolation value can be obtained than the conventional, e.g., linear interpolation, so an inexpensive and high-quality electronic camera can be provided.

[0024]

The present invention is not limited to the above embodiment. In the above embodiment, only an example of a one-dimensional 3rd-order polynomial has been described as an approximate expression. However, the polynomial can be extended to a polynomial of 4th- or higher order.

- 13 -

Interpolation by a multi-dimensional polynomial more than a two-dimensional polynomial is also possible. If not an approximate expression by a polynomial but a more accurate approximate expression using another appropriate function (e.g., an exponential function) is obtained, it is very effective to use the approximate expression and give the interpolation coefficient as a table.

[0025]

Various changes and modifications can be made without departing from the spirit and scope of the present invention.

[0026]

[Advantages of the Invention]

Following advantages are obtained from the present invention.

[0027]

According to the present invention, an inexpensive and high-quality image electronic camera can be provided by enabling pseudo 3-CCD processing, performing high-quality interpolation by an approximate expression using a higher-order polynomial.

[0028]

In addition, interpolation calculation is executed by looking up a table prepared in advance to avoid complex calculation. Hence, this allows high-speed processing and requires no high-performance arithmetic element.

[Brief Description of the Drawings]

[FIG. 1]

A schematic block diagram showing the system arrangement



- 14 -

of an electronic camera according to an embodiment of the present invention.

[FIG. 2]

Graphs showing one-dimensional interpolation models.

[FIG. 3]

A block diagram showing the arrangement of an interpolation calculation circuit 90 in the present invention.

[FIG. 4]

Views for explaining pseudo 3-CCD processing using interpolation calculation by an approximate expression using a higher-order polynomial.

[FIG. 5]

A view showing for explaining the interpolation method for each of R, G, and B colors.

[FIG. 6]

A view showing for explaining another interpolation method for each of R, G, and B.

[FIG. 7]

A view showing for explaining still another interpolation method for the G.

[FIG. 8]

A schematic view showing the flow of pseudo 3-CCD processing.

[Explanation of Reference Symbols]

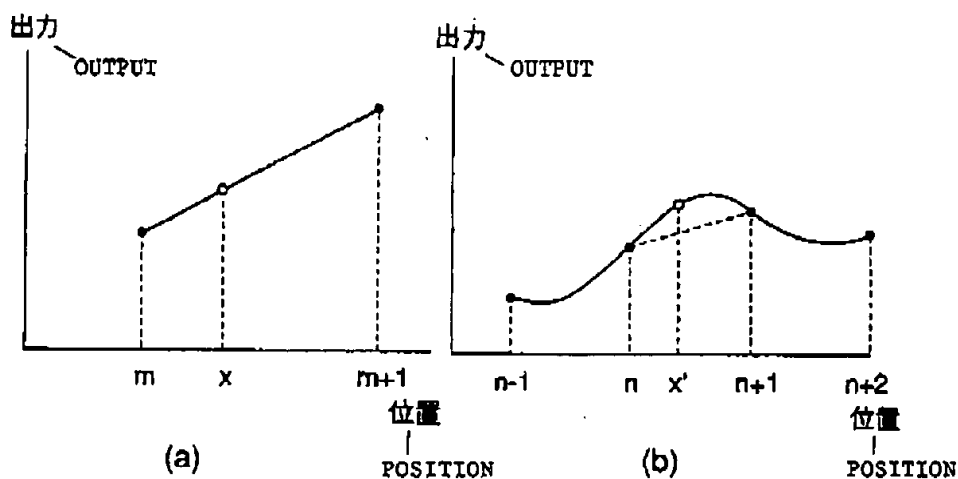
- 11: Image sensing lens system
- 12: Image sensing element
- 13: Image sensing circuit
- 14: A/D converter

- 15 -

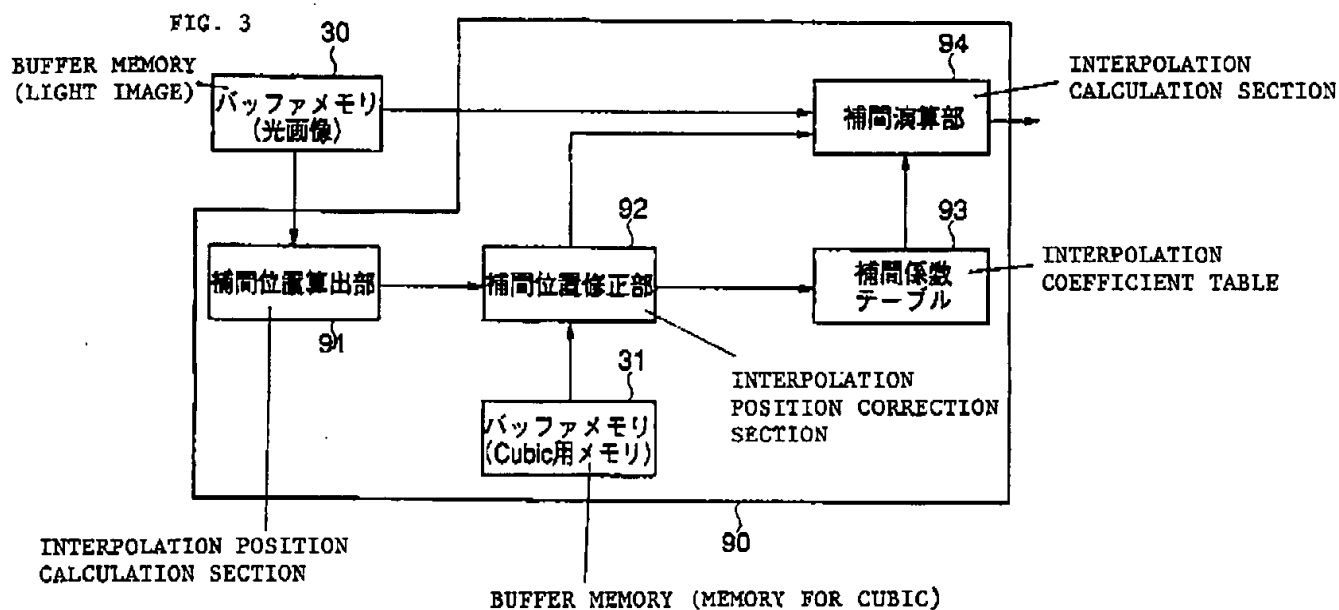
- 20: Detachable memory
- 21: Interface (I/F)
- 22: Card slot
- 30: Internal memory
- 31: Memory area for interpolation processing
- 40: Compression/expansion circuit
- 50: LCD
- 51: Video memory
- 52: Video output circuit
- 53: External terminal
- 70: System controller
- 73: Operation section
- 71: Electronic flash light-emitting section
- 61: External interface (external I/F)
- 80: Power supply section
- 81: Camera battery



【図2】 FIG. 2

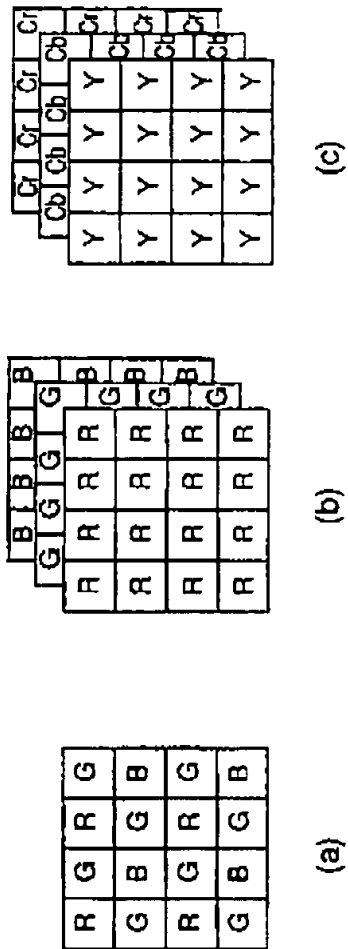


【図3】



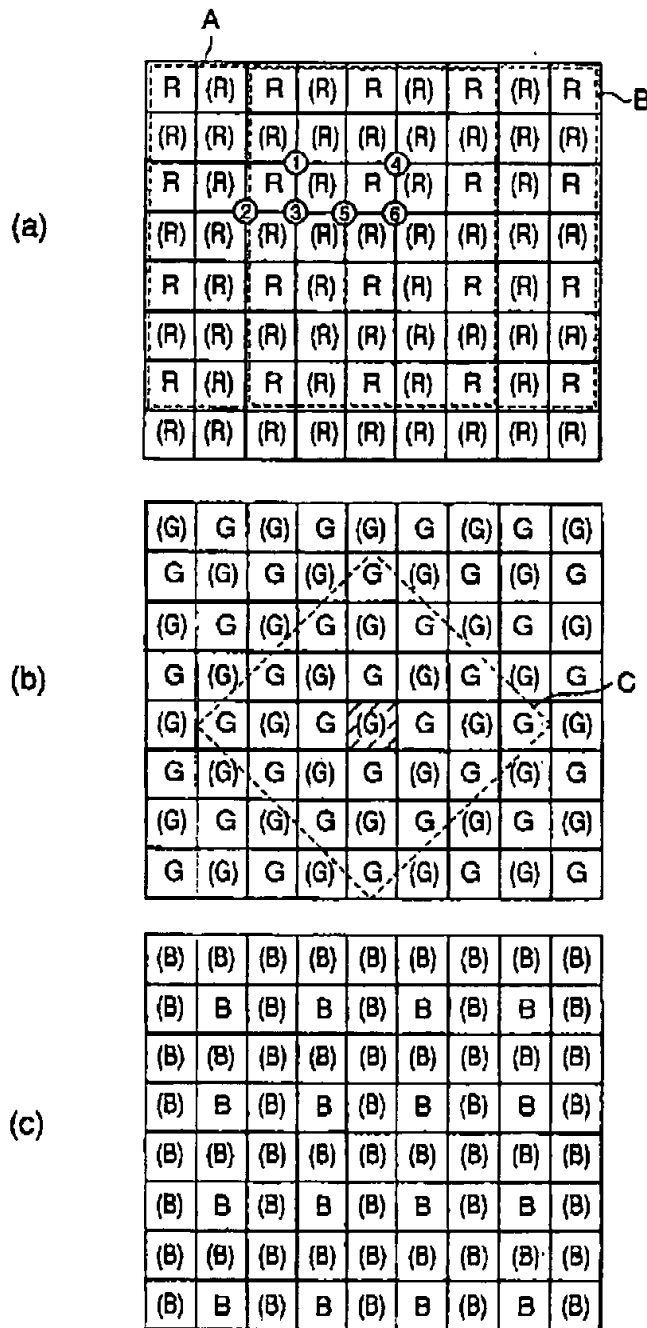
【図 4】

FIG. 4

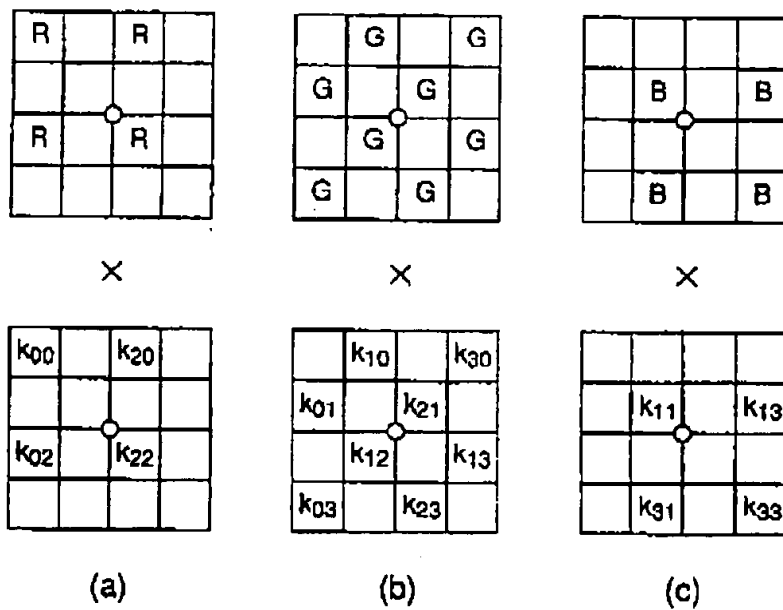


【図 5】

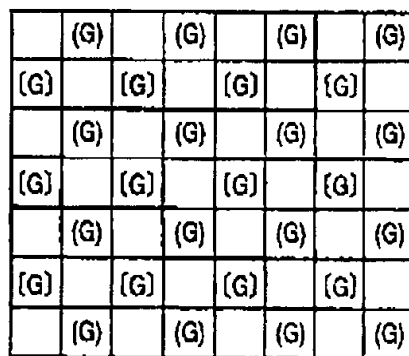
FIG. 5



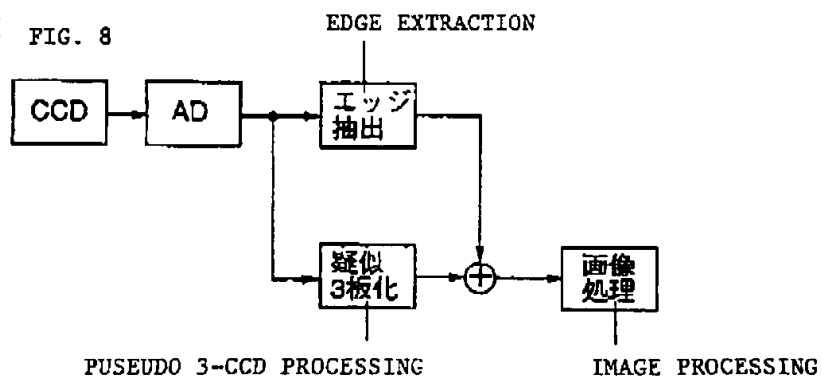
【図 6】 FIG. 6



【図 7】 FIG. 7



【図 8】 FIG. 8



[Document] ABSTRACT

[Abstract]

[Object] To provide an inexpensive and high-quality image electronic camera by pseudo 3-CCD processing an image photographed by an image sensing element composed of at least a single panel.

[Means for Achieving the Object] An electronic camera that comprises an image sensing element 12 composed of a single panel and having a pixel corresponding to at least three different color information, the camera further comprises an interpolation means 90 for generating a plane that corresponds to number of all pixels by interpolation processing based on an approximate expression including a polynomial of at least 3rd-order with use of pixel values having color information same as that of the pixel.

[Elected Figure] FIG. 1



APPLICANT'S PAST DATA

Identification Number [000000376]

1. Date of Change August 20, 1990

[Reason for Change] New Registration

[Address] 43-2, Hatagaya 2-chome,  
Shibuya-ku, Tokyo

[Name] OLYMPUS OPTICAL CO., LTD.